Fort McMurray

FLOOD DAMAGE REDUCTION PROGRAM

PHASES I, II AND III

INTERIM REPORT OF THE STUDY TEAM

Alberta
ENVIRONMENT

November
1983

FORT MCMURRAY FLOOD DAMAGE REDUCTION PROGRAM

INTERIM STUDY TEAM REPORT

SYNOPSIS

This report presents preliminary findings of the Fort McMurray Flood Damage Reduction Prog The program has been underway for about 18 months and is jointly funded by the City of Fort McMurray and Alberta Environment.

During the first three phases of the program damage estimates were made for flooding up to the 1 in 100 year level. Average annual damage was estimated at 5.75 million dollars. Various flood damage reduction alternatives were analyzed including both structural and non-structural methods. The analysis indicated that a dyke outside of the river channel is the most attractive alternative from both an economic and non-economic standpoint. The major outstanding problem with the dyke alternative is the risk of dyke failure. This risk can be minimized by building the dyke higher than the 1:100 year level, having rapid evacuations based on forecasted water levels and development controls on land use in high risk areas. An ice control weir upstream of the city represents a less economic, less effective and more environmentally harmful alternative but one which has less risk associated with it. This report presents brief summaries of the analysis carried out for all the possible alternatives.

Further studies are proposed which will detail the benefits and costs, analyze the risk involved, resolve any uncertainties and address any public concerns.

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1.0 INTRODUCTION

1.1 BACKGROUND

The City of Fort McMurray is subject to periodic flooding by the Clearwater River. As recently as 1977, parts of the Lower Townsite area have been inundated by high flows in the Clearwater River occurring in combination with the formation of an ice jam in the Athabasca River downstream from the City.

A number of previous studies of this problem have been conducted. The most recent was undertaken at the request of the Alberta Planning Board (APB) and was coordinated by the Fort McMurray Flood Damage Abatement Technical Committee. In June 1979, this committee concluded that the most economic methods of preventing flood damage up to the 1:100 year flood level of 252 m were a dyke with a cut-off wall, or alternatively an ice weir on the Athabasca River upstream of the City. The committee recommended that the dyking alternative be rejected due to the risks involved in overtopping. It further recommended that if flood damage reduction was required, that further investigations be made of the ice weir.

The role of studying these and other recommendations fell to Alberta Environment who undertook two studies, the first to determine the impact of the ice weir on fish migration, and the second to take the ice weir to the preliminary design level. An analysis carried out by Alberta Environment in June 1980 indicated that without consideration of the effect of the proposed weir on fish, the cost benefit ratio of the proposed weir was 0.61 to 1. As well, the fisheries impacts were considered to be sufficiently severe that Alberta Environment

recommended to the APB that this particular solution should not be proceeded with until detailed studies were conducted on other potential solutions, both structural and non-structural.

Consequently, a study team composed of representatives of the City of Fort McMurray and Alberta Environment was structured to conduct jointly funded studies.

1.2 OBJECTIVE AND SCOPE

The purpose of the Flood Damage Reduction Program is to determine the most viable structural or non-structural method for reducing potential flood damage losses in the City of Fort McMurray.

Specifically it has or will consist of studies to meet the following objectives:

1) obtain up-to-date, accurate land use information and flood risk mapping;
2) obtain up-to-date, accurate flood damage estimates;
3) review the full range of structural and non-structural alternatives and select a short list of viable alternatives;
4) review the viable alternatives with the public;
5) undertake detailed analysis of viable alternatives and a detailed cost benefit analysis and address public concerns;
6) recommend most viable alternative.

To achieve these objectives a multi-phase program was developed and a timetable formulated. The various phases and timetable for completion of each are presented in Figure 1.0. It is anticipated that the entire program will be completed by the end of 1983. Figure 1.1 shows the extent of the study area to be examined.

FORT McMURRAY FLOOD DAMAGE REDUCTION PROGRAM SCHEDULE

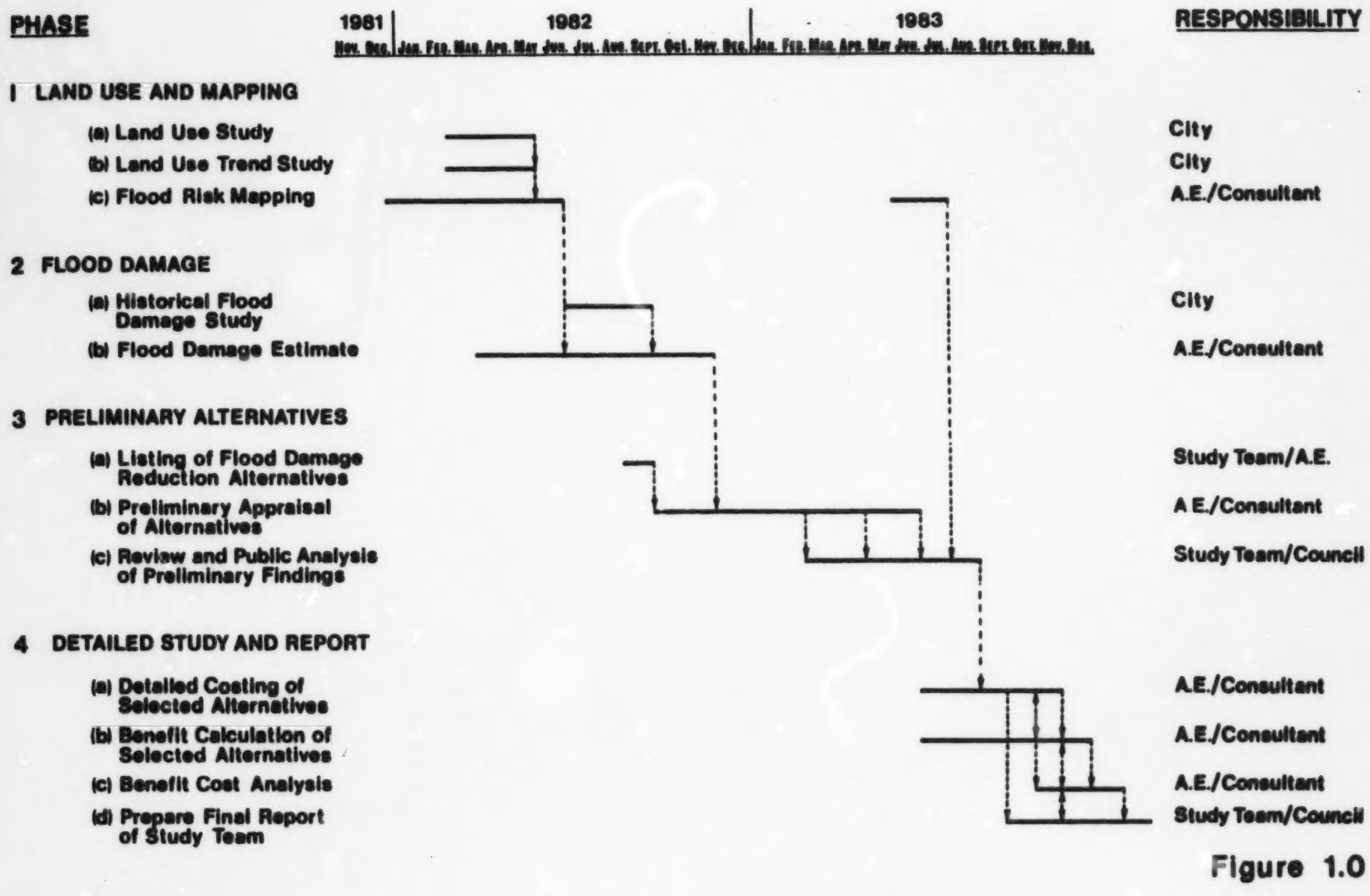
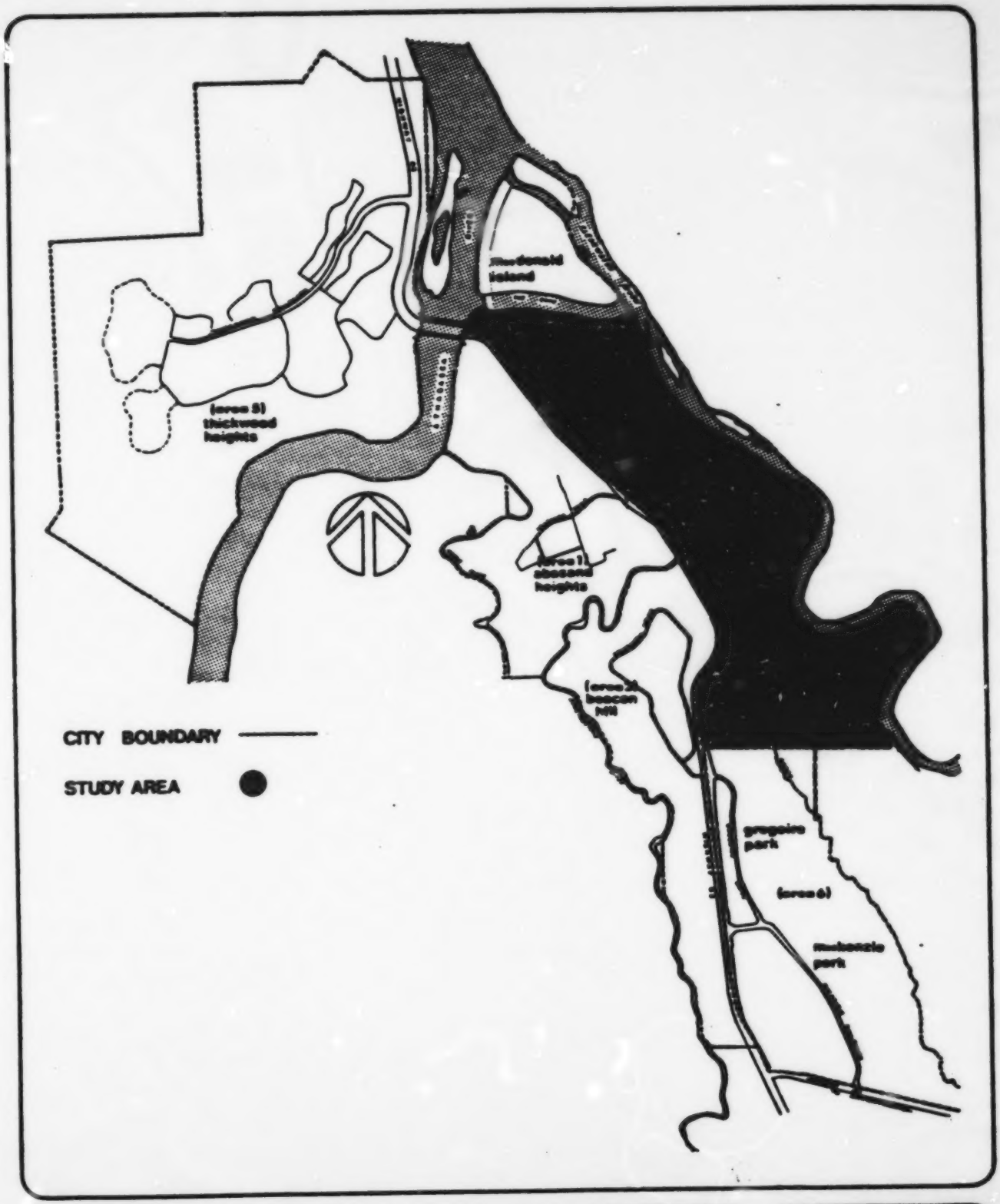


Figure 1.0



STUDY AREA

Figure 1.1

This interim report presents a summary of the studies carried out under the program to date which covers Phases I, II and III.

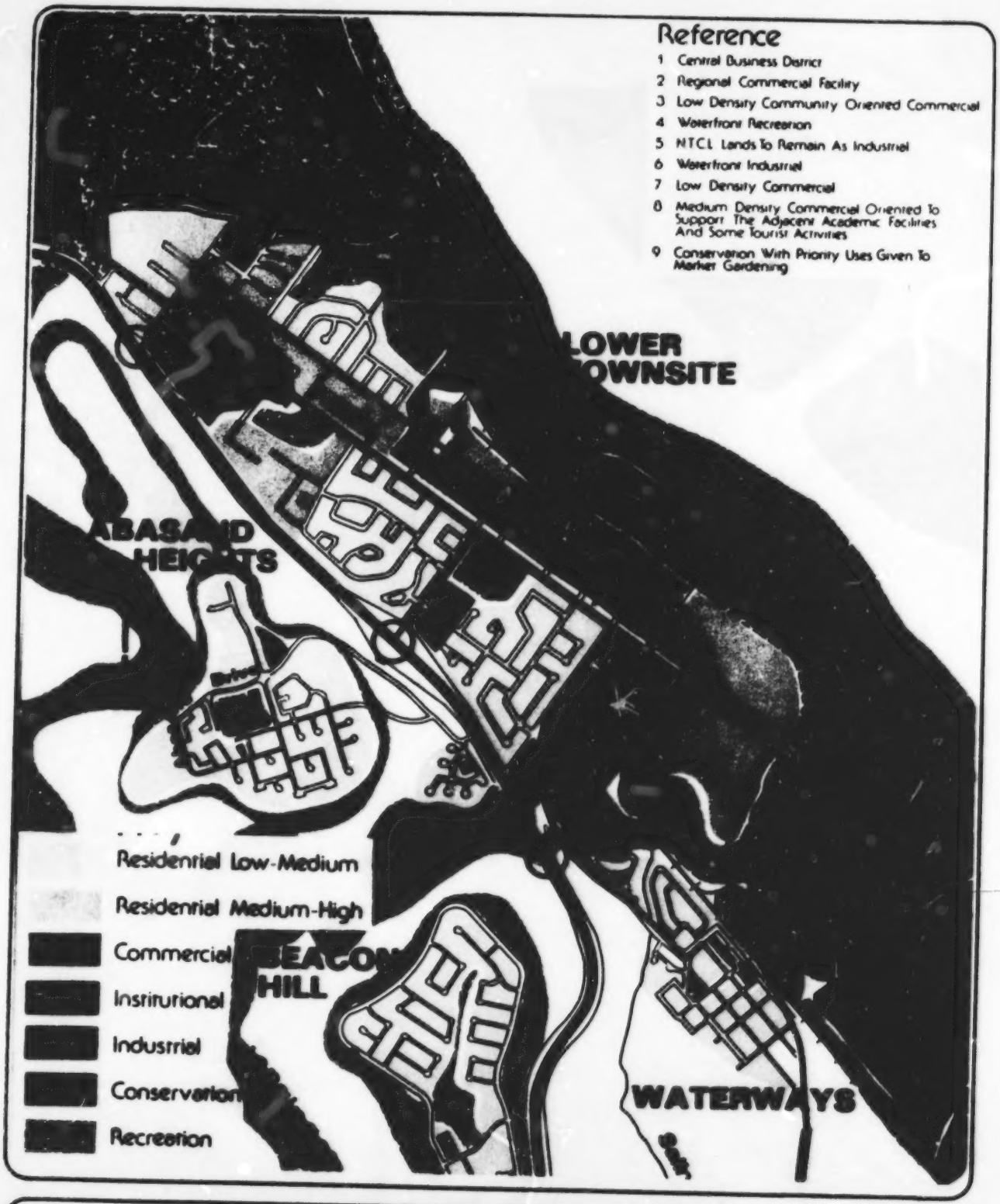
2.0 LAND USE AND MAPPING

2.1 STUDIES CONDUCTED

The evaluation of flooding potential in any area requires a technically accurate detailed flood risk map. Such a map is used to determine flood depths for each structure in the flood prone area. Damage estimates are then obtained for a number of flood levels which are averaged according to their expected return period to obtain a value for average annual damages. The evaluation of flood damage potential also requires an understanding of the existing land use and land use trends in the area. Phase I, therefore, consisted of a mapping component and a land use study. Much of the information required for the land use part of Phase I was taken from material prepared by the City of Fort McMurray for the creation of the General Municipal Plan (see Figure 2.0). The General Municipal Plan provides a current assessment of likely future zoning and was developed independent of the Flood Damage Reduction Program.

2.2 TOPOGRAPHIC MAPPING

The maps used in the development of the General Municipal Plan do not have sufficiently precise elevation control for flood risk mapping purposes. Consequently, it was necessary to acquire a map having 0.5 m contour intervals at a 1:2,000 scale. The firm of Underwood MacLellan (UMA) was engaged to carry out this mapping. A 1:2,000 flood risk map of the Lower Townsite and Waterways area was developed. The map series consists of 13 topographic sheets and includes flood lines. Copies of



General Municipal Plan

Figure 2.0

these maps are available from the Technical Services Division of Alberta Environment.

A smaller, 1:5,000 scale flood risk brochure map of the flood prone areas of the City is being prepared and will be made available for wide public distribution.

3.0 FLOOD DAMAGE ESTIMATES

3.1 STUDIES CONDUCTED

An accurate assessment of the potential damage from floods is required to determine the magnitude of remedial works or measures justified and to determine the benefits of alternative works or measures. There are essentially two ways to make an assessment of flood damage potential. The first is to examine the damage claims for previous flooding events and then to extrapolate these values to potential future flood levels.

The limitations to this method are:

1) in any natural disaster there are differences between the actual damage and the compensation. These differences arise from different rules governing the payment of compensation.
2) in a growing country such as Canada where major development has occurred in the past 20 years often only recent flood events have had damages of any consequence. These events however may not be hydrologically significant or typical.
3) in response to previous flooding, actions may have been taken to alter the flood damage potential (ie. land use zoning, river engineering works).

The second method is to analyze the damage potential for a range of theoretical floods based on a sample of the structures, that would be affected making appropriate assumptions for infrastructure damages (ie roads, sewers, utilities etc.) and other indirect costs such as lost time.

The limitations to this method are:

1) To achieve statistical accuracy, a large amount of expensive surveying is often required.

2) It is often difficult to accurately assess damage potential for some types of structures and some types of contents.

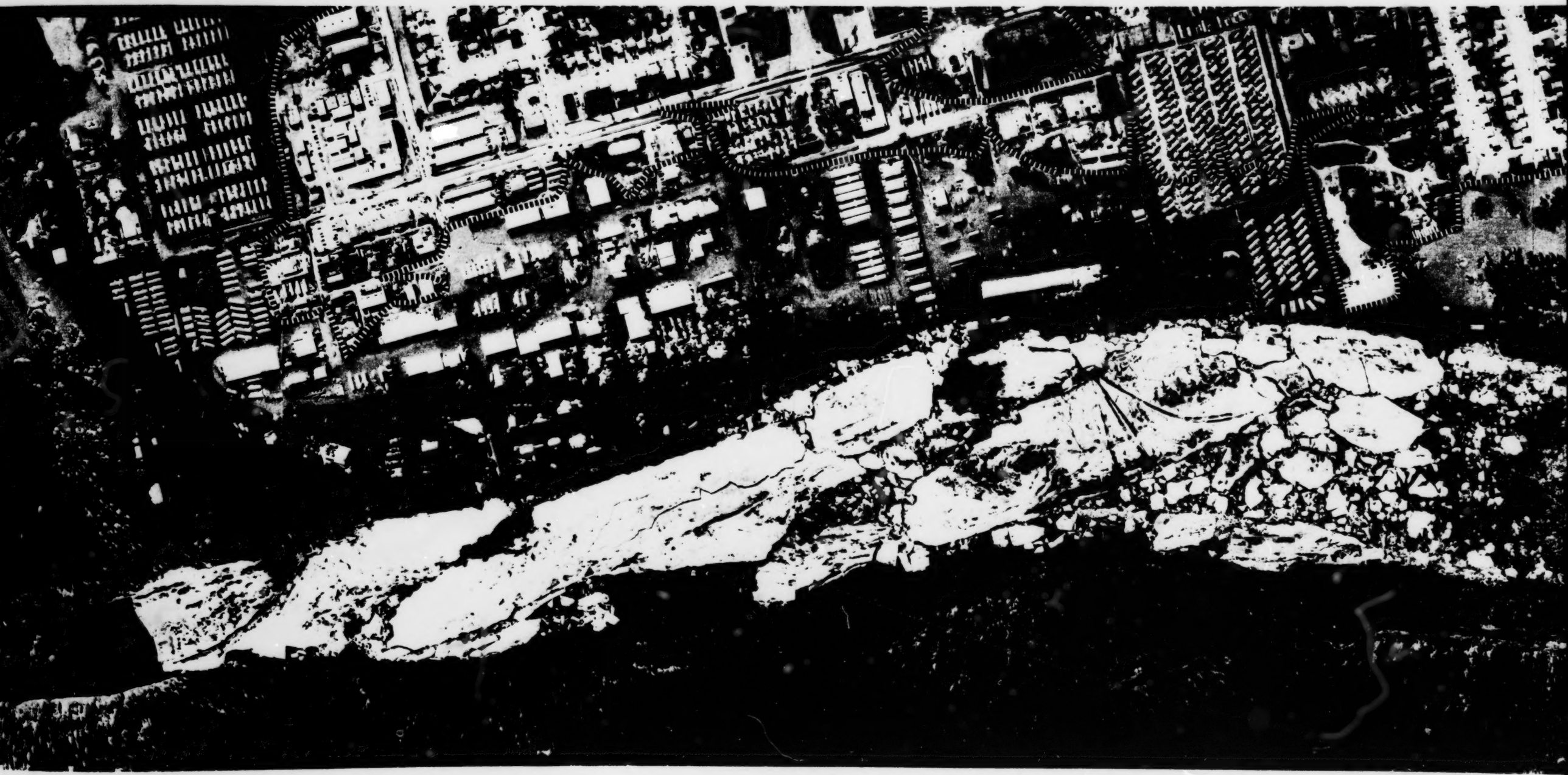
In almost all flood studies the second method is chosen in which a survey is taken and structure and content damage estimates are made.

The 1977 flood is the most recent flood on record and its extent is shown on Figure 3.1. This flood approximates the 1:17 year flood with a flood elevation of 248.0 m. The flood damage compensation for this flood totalled $1.5 million. The breakdown of this is as follows:

Provincial and Associated Costs	$ 20,000
Compensation to Individuals	1,235,000
Compensation to Municipality	245,000
Total	$1,500,000

These figures could be extrapolated and then averaged to determine average annual flood damage potential. However, as explained above, they do not adequately show the amount of damage that actually occurred but rather only what could be claimed for. To assess the potential flood damage the Study Team engaged the services of a consultant to conduct a major field and office evaluation.

The primary purpose of this second phase of the program was to estimate the total direct and indirect flood damage potential for the Lower Townsite and Waterways areas if inundated by a prescribed range of floods up to and including the 100 year flood.



1977 FLOOD

..... APPROXIMATE EXTENT OF FLOOD

Figure 3.1

The assessment of total flood damages required consideration of damage to residential, commercial and public buildings and to the infrastructure (roads, utilities, etc.). Damages were estimated from damage - frequency curves created specifically for Fort McMurray. Tasks for this work included:

1) An inventory of all residential and commercial structures within the flood study area.
2) A level loop survey of all structures to within 0.1 m accuracy.
3) Creation of damage curves for residential and commercial structures by means of a detailed contents and structure survey.
4) Generation of statistically significant damage curves for residential structures to obtain 90% accuracy in the total damage estimate for residential units.
5) Assessment of flood damages to residential and commercial structures for a range of flood frequencies as well as damages to infrastructure, utilities, and indirect damages.
6) Calculation of average annual damages for the study area.
7) Analysis of future damage potential within the study area.

3.2 STUDY RESULTS

The Lower Townsite and Waterways area has 3391 residential units subject to flooding at the 1:100 year level. These include single family homes, mobile homes, apartment towers and walk-ups. A category for each type of structure was established, and the units were surveyed, categorized and inventoried. The following table presents the

residential classification system and Figure 3.2 shows pictures of typical units.

FORT McMURRAY RESIDENTIAL CLASSIFICATION SCHEME

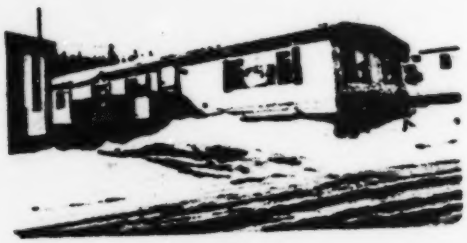
Class	General Description
AW 1* AW 2 AW 3	Typical custom constructed housing built, for the most part, during the 1970's architecturally designed with control of materials selection and consideration of increased insulation values, vapour seals, passive and active solar heating systems. Interior materials, finishes and general decor reflect an above average upgrading to the personal requirements of the owner. These houses represent the high end in terms of real estate values.
BW 1 BW 2 BW 3	Typical subdivision construction of the 1960's, constructed by the developer or builders from a selection of stock design plans in accordance with design guidelines for exterior materials control. Exterior materials are typically aluminum and wood siding, stucco and brick veneer. The size of the unit, style and lot size set the average real estate value. These houses have average insulation values and represent middle real estate values.
CW 1 CW 2 CW 3	Typically constructed during the 1940's to 60's, units are of average design, less than average m^2 (≤300), have a low level of insulation value, no vapour barrier or vapour seal and generally have exterior finishes of wood siding and stucco. Generally, these units are located in the core area have a high land to building value ratio and represent the lower end real estate values. Many units will have upgraded interior finishes.
D 1	Mobile Home, Double Wide - Good Quality
D 2	Mobile Home, Double Wide - Poor Quality
D 3	Mobile Home, Single Wide - Good Quality
D 4	Mobile Home, Single Wide - Poor Quality
MA	Apartment Towers
MW	Walk-up Apartments, Row Townhouses

* 1, 2, 3 denotes above average, average and below average quality within the A, B and C categories. This differentiation was later dropped for sampling purposes.

Once each unit was surveyed, a random sample was chosen to be inventoried for contents. Previous flood damage studies have shown that typical contents can be found in most residential units. Average costs for rugs, furniture, TV's, etc. were found and damage estimates were developed for each type of unit. As well the expected structural damage was estimated for each type of structure. This data was evaluated and depth-damage curves were developed. An example of such a curve appears as Figure 3.3.

A similar exercise was conducted for all institutional, commercial and industrial buildings. These building types are more difficult to

BW

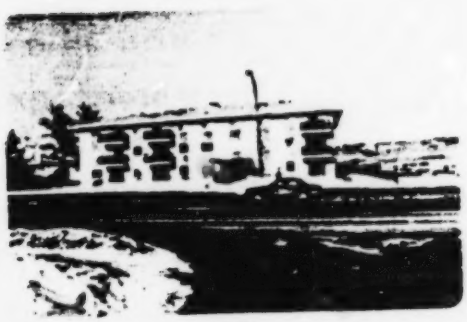


D1

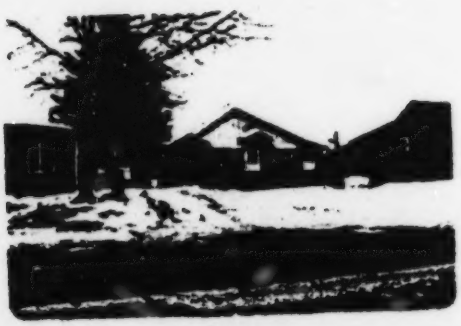
BW

D3

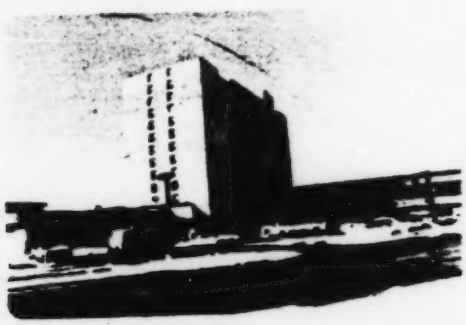
CW



MW

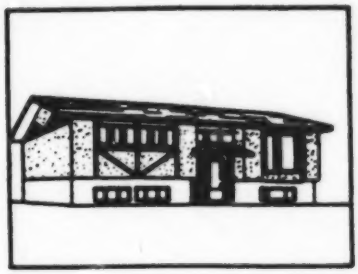


CW

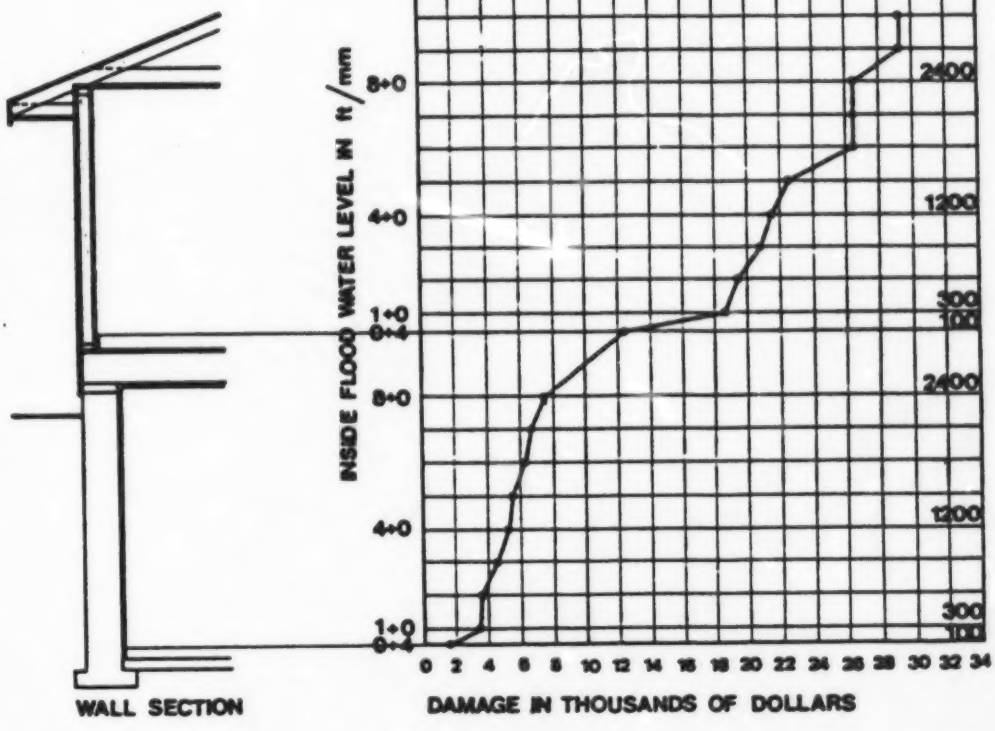


MA

Figure 3.2



AVERAGE STRUCTURAL DAMAGE
Building Type: BW(1) Bungalow



Sample Structural Damage Curve

Figure 3.3

categorize than the residential units. Twenty categories were established including drug stores, restaurants, general offices and furniture stores. Surveys and inventories were made for all the categories and damage curves were developed.

The calculation of infrastructure damage was based on the results of the 1977 and 1979 floods. Indirect damages include such things as lost time, administrative costs and net loss of normal profit. Indirect damages costs were calculated as percentages of direct costs for each type of damage. For example, indirect residential damage was set equal to 20% of direct residential damage.

Once all of these factors have been accounted for flood damage estimates can be made for each flood level. The following table gives estimated damages for flood that can be expected every 25, 50 and 100 years respectively.

FORT McMURRAY TOTAL FLOOD DAMAGES

DESCRIPTION	FLOOD	1:25 YEAR	1:50 YEAR	1:100 YEAR
Residential	Direct	$ 9,910,000*	$ 38,027,000	$ 65,619,000
	Indirect (20%)	1,982,000	7,605,000	13,124,000
Commercial	Direct	8,209,000	33,426,000	66,511,000
	Indirect (41%)	3,366,000	13,704,000	27,269,000
Infrastructure	Direct	4,800,000	5,520,000	10,320,000
	Indirect (25%)	1,200,000	1,380,000	2,580,000
Sub-Total	Direct	22,919,000	76,973,000	142,450,000
	Indirect	6,548,000	22,689,000	42,973,000
Utilities	Direct	2,292,000	7,697,000	14,245,000
	Indirect (20%)	458,000	1,539,000	2,849,000
Highways	Direct	2,292,000	7,697,000	14,245,000
	Indirect (25%)	573,000	1,924,000	3,561,000
TOTAL	Direct	27,503,000	92,367,000	170,940,000
	Indirect	7,579,000	26,152,000	49,383,000
COMBINED		35,082,000	118,519,000	220,323,000

* to nearest $1,000.

Damages that can be expected over a typical 100 year period are summed and then divided by 100 to give the average annual damage. Average annual damages for the present level of development can be calculated from the values in the above table. Future damage assessments however, require assumptions regarding zoning and city growth. For the purposes of this study three alternatives were examined. They were: the existing zoning, a re-zoning based on the general municipal plan and finally a radical re-zoning where large areas of the lower townsite were downzoned to public service land. All of the above zoning scenarios were combined with population projections currently used by the city in their planning studies. The results of this analysis are listed in the following table.

FORT MCMURRAY TOTAL FUTURE FLOOD DAMAGES

Scenario	1:25 Year	1:50 Year	1:100 Year	Average Annual Damages
1982 Flood Damages	35,082,000	118,519,000	220,327,000	5,750,000
Future Damages Existing Zoning	80,030,000	279,232,000	544,886,000	12,700,000
Future Damages Re-Zoning #1	78,263,000	272,456,000	533,060,000	12,299,000
Future Damages Re-Zoning #2	---	---	---	3,995,000

4.0 PRELIMINARY APPRAISAL OF ALTERNATIVES

4.1 STUDIES UNDERTAKEN

Once potential damages had been accurately assessed it was possible to make a preliminary benefit-cost analysis of various alternative flood damage reduction works and measures. The first step was to make a detailed list of the various alternatives. As indicated earlier, previous work had been done on a number of the alternatives. However, it was necessary to bring each measure up to the same level of detail. The following is a list of the alternatives studied.

1. An ice weir upstream of the Lower Townsite on the Athabasca River;
2. Floodplain zoning;
3. Dyking inside the river channel;
4. Dyking outside the river channel;
5. Floodplain zoning in conjunction with a low level dyke;
6. Floodplain zoning in conjunction with flood proofing;
7. Contingency measures;
8. Downstream blasting to remove ice jams;
9. Downstream channel improvements;
10. A multiple objective storage structure upstream at Crooked Rapids;
11. Upstream storage on the Clearwater River;
12. A dual function ring road and dyke.

4.2 STUDY RESULTS

Each alternative was studied within a framework developed to maintain consistency and facilitate direct comparison. This framework is presented as follows:

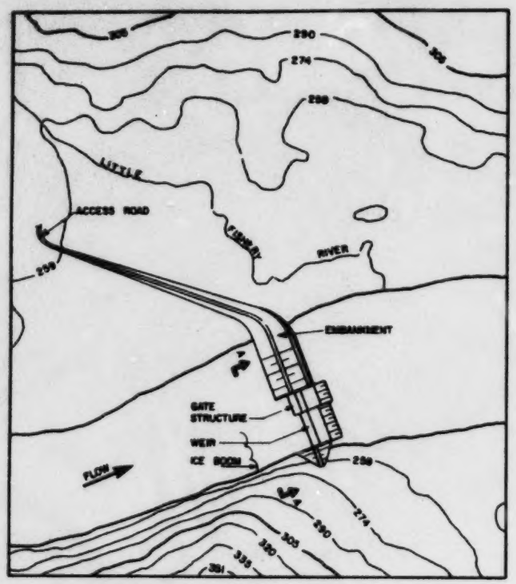
1. general
2. description of alternative
3. effectiveness
4. costs - construction, operation and maintenance
5. appraisal of economic efficiency - net present value and discount rate
6. implementation - reconstruction, construction, operation
7. environmental aspects - ecological, social, aesthetics
8. uncertainty - risk, loss of life

Details of this work can be found in the technical report "Preliminary Appraisal of Alternatives." The following is a brief summary of the significant findings for each alternative.

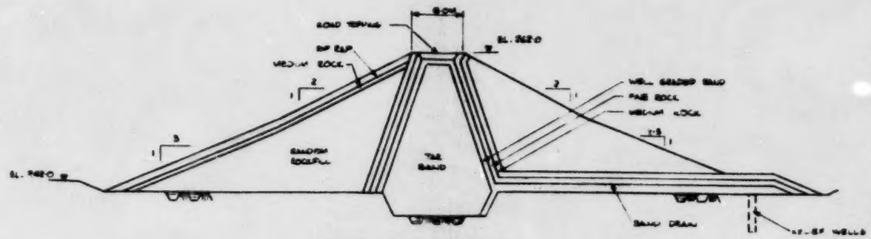
4.2.1 Ice Control Structure

This alternative was proposed by a previous study (Fort McMurray Flood Damage Abatement Study) and consists of an embankment, a 68 metre wide stop log gate and 115 metre wide overflow weir (see Figure 4.1). It would be located on the Athabasca River just above the Little Fishery River.

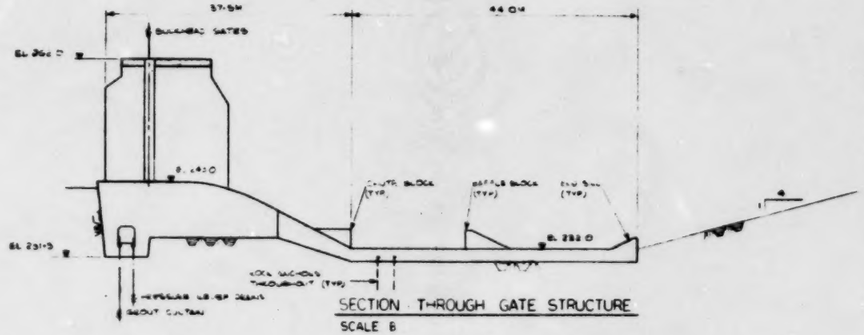
A major problem with this alternative is that it is unclear to what extent flood damage would be reduced. It may be necessary to have some form of increased downstream protection such as small dykes or re-zoning



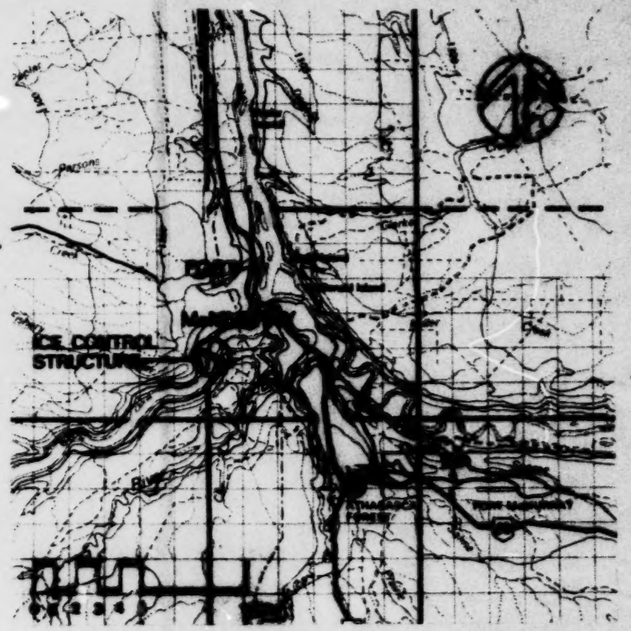
ICE CONTROL STRUCTURE LAYOUT
SCALE A



DYKE CROSS-SECTION
SCALE B

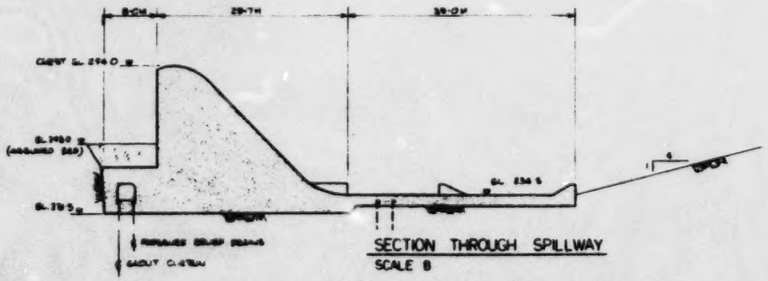


SECTION THROUGH GATE STRUCTURE
SCALE B

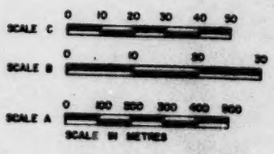


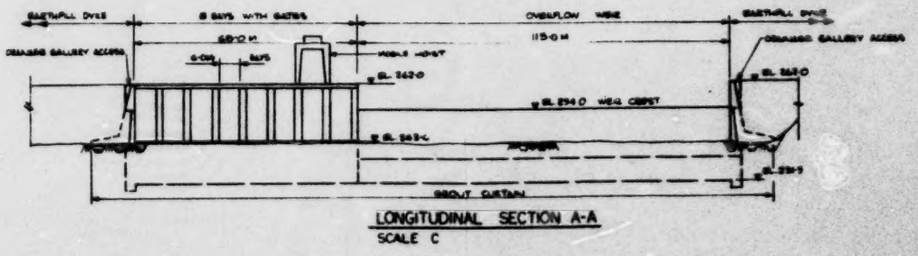
KEY PLAN

SOURCE: ACRES CONSULTING SERVICES LTD.



SECTION THROUGH SPILLWAY
SCALE B





LONGITUDINAL SECTION A-A
SCALE C

ICE CONTROL STRUCTURE

Figure 4.1

to achieve the same level of protection available from other alternatives.

The ice weir at present has a benefit-cost ratio of approximately 0.65 but it will require extensive modelling to determine the exact extent of flood damage relief it provides. This alternative would take several years to implement and would seriously disrupt fish migration in the Athabasca River.

The major advantage of this alternatives is that it would not present an aesthetic problem as it would be out of site from most of the town.

4.2.2 Dyking Inside the River Channel

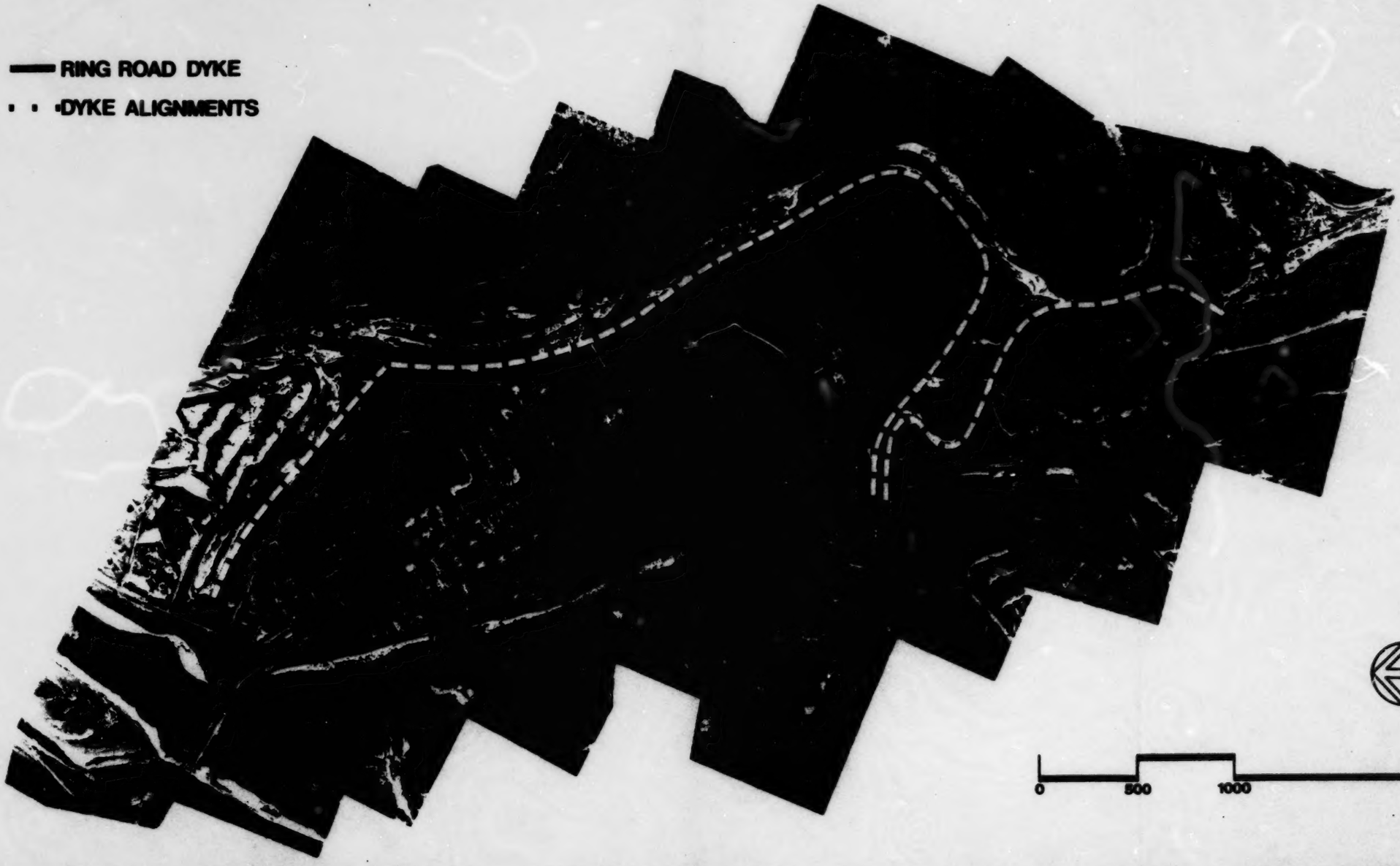
This alternative is a large earthfill dyke that would follow the alignment shown on Figure 4.2. The dyke would be landscaped and have a bicycle/walking path on top. An example of a typical landscape appears as Figure 4.3.

A geotechnical overview of the area indicates that there is sufficient material to construct such a dyke. Potential seepage and how it would be handled was analyzed. This included costing facilities to pump out water that would seep through the dyke. At a number of locations the CNR railway crosses the dyke and closures were designed and costed.

The dyking system has a benefit cost ratio of 1.62. It can be implemented relatively quickly and with little difficulty. Its environmental impacts would be insignificant and confined primarily to the construction phase. Aesthetic judgments about it are highly

RING ROAD DYKE

DYKE ALIGNMENTS

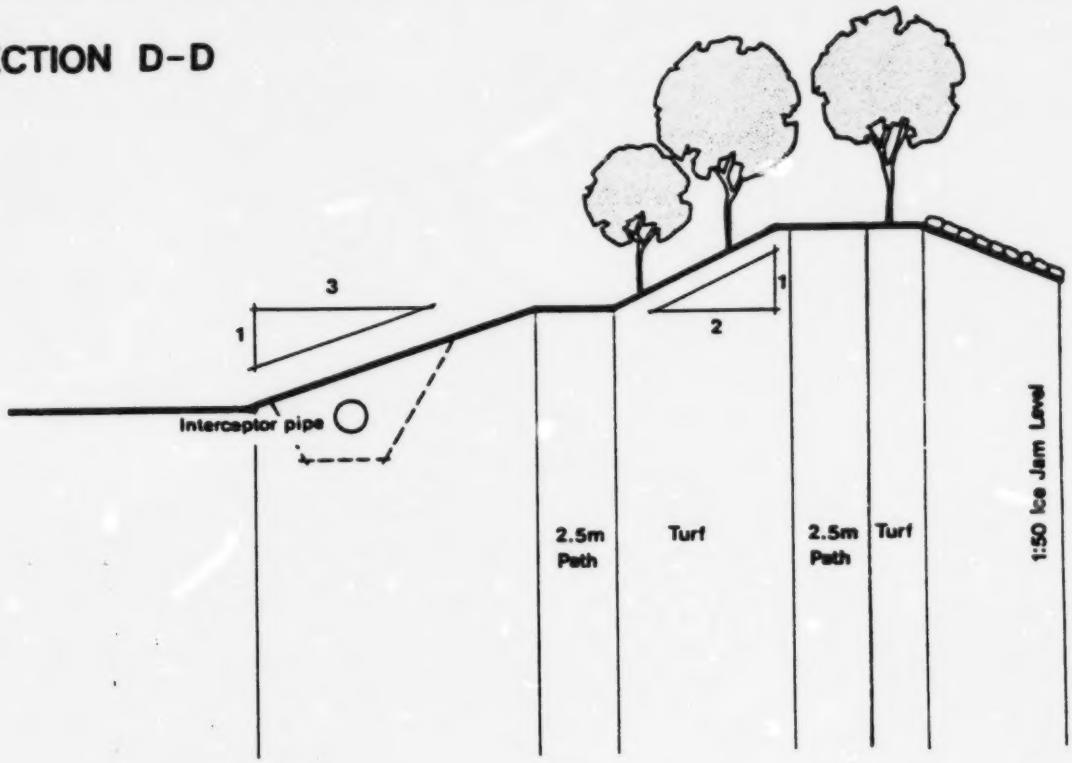


0 500 1000 2000m

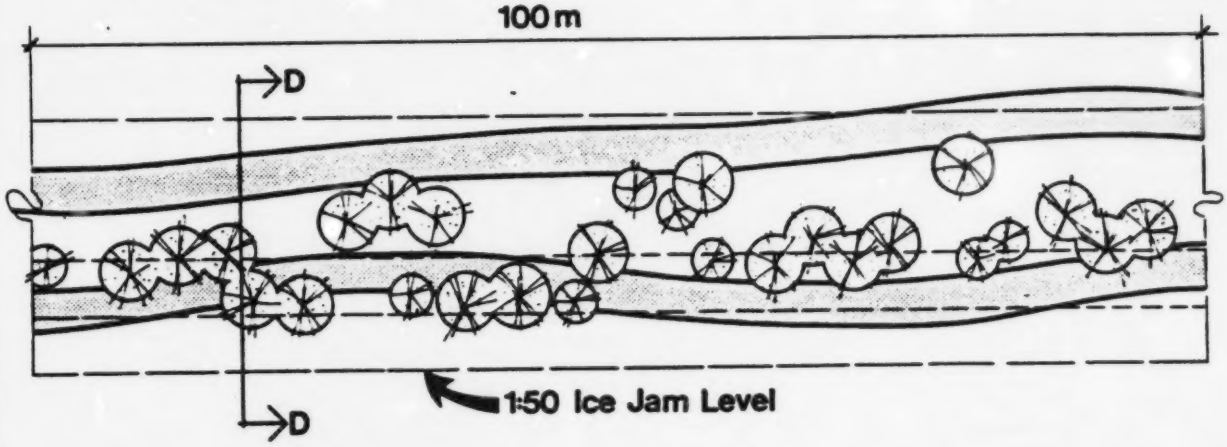
DYKE ALIGNMENT LOCATION PLAN

Figure 4.2

SECTION D-D



PLAN-100m MODULE



PLANT MATERIAL

Deciduous	Large	20
	Medium	8

DOUBLE PATHWAY MODULE

Figure 4.3

subjective, but appropriate landscaping would significantly lessen any impact.

The major disadvantage of this alternative is the risk of loss of life due to the dyke being overtopped. Under present flood conditions the water rises slowly enough that people in the lower townsite area would have a good chance of leaving the area. No matter how high a dyke is built, the possibility exists that there will eventually be a flood that is so large that even the dyke would not hold it back and water would overtop and breach the dyke. If the residents had not been previously evacuated the risk of loss of life would be very high. In other communities behind high dykes, evacuations are routinely carried out but these communities have much more flood warning than would be available in Fort McMurray. It is essential that if this alternative is selected that a flood forecasting and evacuation plan be developed. Although the risk of overtopping cannot be eliminated, it may be possible to design a dyke that would not be subject to breaching or failure. Alternatively it would be possible to design a dyke that would offer protection up to the 1:1000 year event. Once a final design is chosen an analysis of the risk involved would be made and appropriate zoning restrictions implemented.

4.2.3 Dyking Outside the River Channel

This dyke is similar to the dyke outlined in the previous section, the only major difference is that the alignment is outside the Clearwater River Channel. Although it removes some land from potential development it has a substantially reduced cost. It represents the most

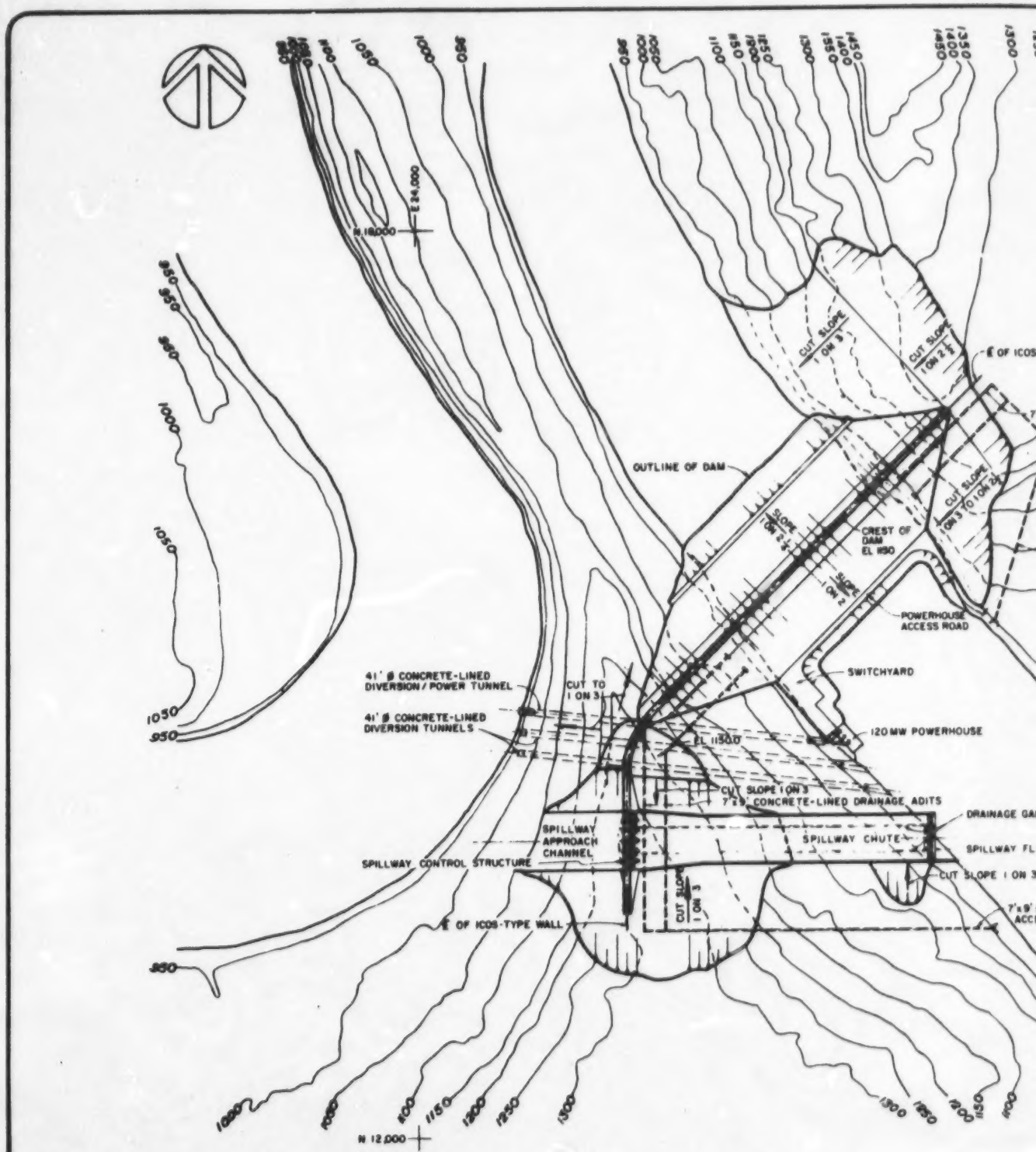
economically efficient alternative by virtue of a benefit-cost ratio of 2.61. All other impacts are similar to the previous dyking alternative.

4.2.4 Downstream Channel Improvements

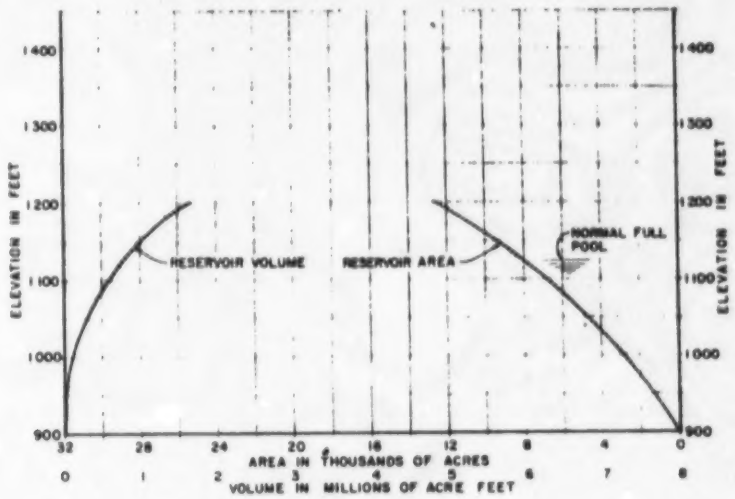
This alternative involves the application of structural modifications to alter the conveyance of ice flows downstream of the confluence of the Athabasca and Clearwater Rivers. This can be achieved by deepening the channel or changing the gradient. A number of measures were evaluated such as the installation of groins, construction of a bypass channel or dredging. The cost of any of these proposals is extremely high (in the order of $110 million) and their effectiveness is uncertain. Detailed modelling would be required to provide an estimate as to the effectiveness of the channel improvements.

4.2.5 Multiple Objective Storage Structure at Crooked Rapids

This alternative is a proposal that dates back to a 1974 report which examined the possibility of building a hydro-electric facility near Crooked Rapids. A fairly detailed layout had been developed and costs estimated (see Figure 4.4). The 1974 costs were updated and compared to the recently proposed Slave River project. The comparison revealed that the Slave River site is superior to the Crooked Rapids Site for hydroelectric generation. The flood control benefits were added to the hydroelectric benefits of the Crooked Rapids project and then it was again compared to the Slave. Even with the addition of flood benefits, the Crooked Rapids project remains more than double the cost per unit of installed hydroelectric capacity of the Slave River Project.



CROOKED RAPIDS DAM



RESERVOIR STORAGE CURVES

NOTES

1. FOR SECTIONS OF DAM SEE FIGURE 7
2. FOR SECTIONS ALONG SPILLWAY AND TUNNELS, AND THROUGH POWERHOUSE SEE FIGURE 8
3. SLOPES ABOVE UPSTREAM PORTALS OF TUNNELS AND ABOVE UPSTREAM SLOPE OF DAM ON RIGHT BANK TO BE CUT TO 1 ON 3. FOR CLARITY CUT LINES NOT SHOWN ON PLAN. SEE SECTIONS FIGURES 7 & 8
4. FOR SLOPE OF FILL OVER CUT AND COVER SECTIONS OF TUNNELS SEE FIGURE 8
5. CONTOURS OBTAINED FROM AIR PHOTO MAPPING BY NORTHWEST SURVEY CORPORATION LIMITED, JUNE 1974. ELEVATIONS ARE ABOVE G.S.C. DATUM
6. RESERVOIR VOLUME CURVES OBTAINED FROM ROUGH CONTOUR MAPS SUPPLIED BY CALGARY POWER LTD
7. SPILLWAY APPROACH CHANNEL & CHUTE TO BE LINED
8. SITE ROADS NOT SHOWN

400 0 400 800 1200
SCALE IN FEET

SOURCE:

ALBERTA DEPARTMENT OF ENVIRONMENT

DRAWING BASED ON WORK CARRIED OUT BY CRIPPEN ENGINEERING LTD

MEDIUM HEAD PROJECT
General Arrangement

Figure 4.4

4.2.6 Upstream Storage on the Clearwater River

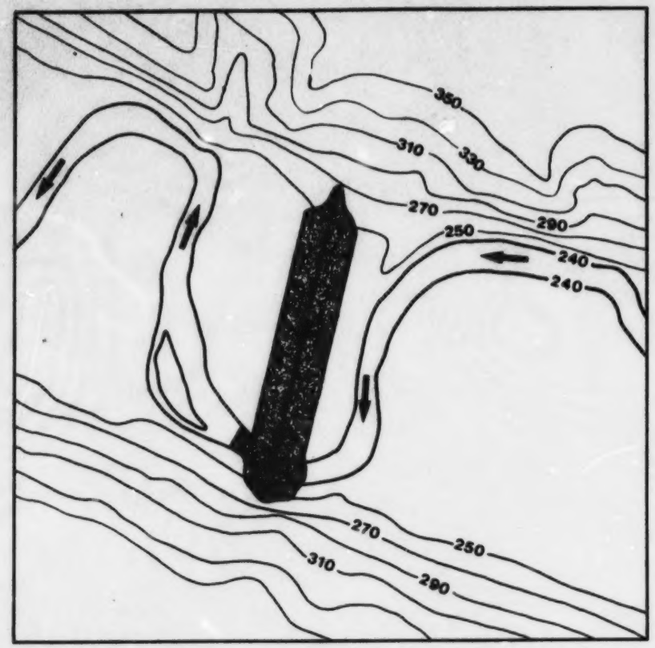
This alternative involves the creation of a man-made impoundment on the Clearwater River. A second structure would be required at the confluence of the Clearwater and Athabasca Rivers. The first structure would to impound the Clearwater River while the Athabasca River was blocked by an ice jam (see Figure 4.5). The second structure would keep the Athabasca River from backing up into the town area. The geotechnical overview established that there is a suitable site and sufficient material to construct these structures. The environmental impact of this project would be severe when it is operated as it would flood large portions of the Clearwater River valley including the Clearwater Indian Reserve.

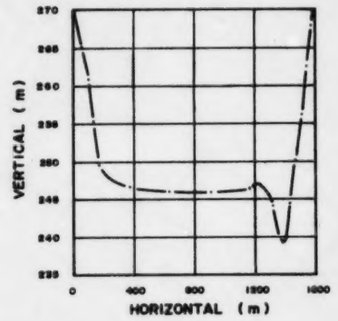
The cost of this alternative would be about $87 million which would give it a benefit-cost ratio of 0.61. It is less economically attractive than the ice control structure but since it is not expected to interfere with fish migration it has lower biophysical impacts.

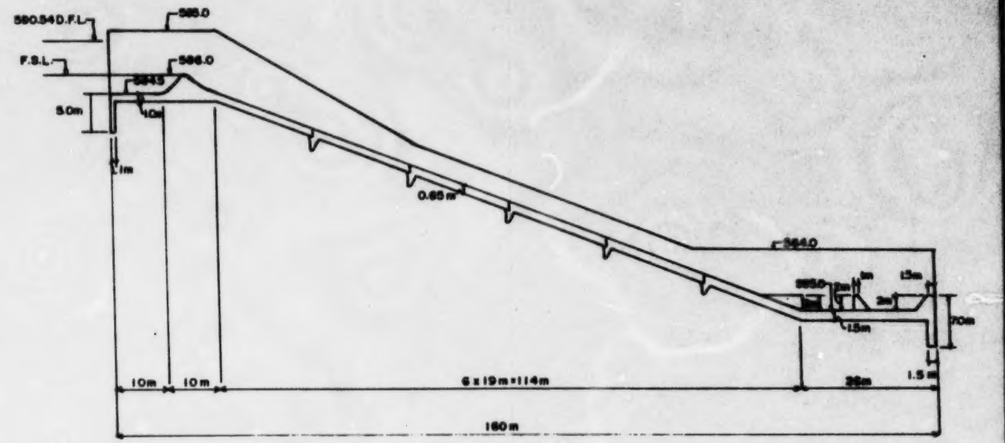
4.2.7 Dual Function Ring Road and Dyke

The City of Fort McMurray conducted a Transportation System Study in April 1981. One alternative identified in this study was a Lower Townsite Loop Road. If this road were built to the appropriate elevation it could serve the dual function of a ring road and dyke (see Figure 4.2). Flood protection similar to the other alternatives would require some additional dyking at the north end of the road and in the south to protect Waterways.

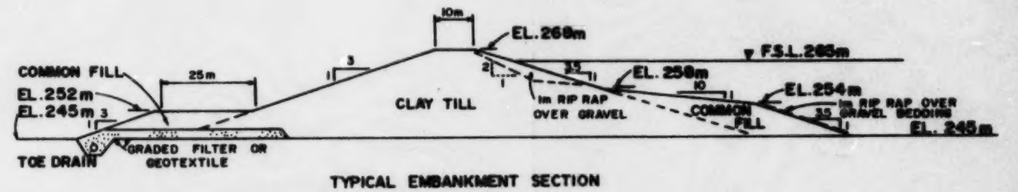
The additional costs to the ring road would be approximately $17.1 million. This would result in a benefit-cost ratio of 1:16. A



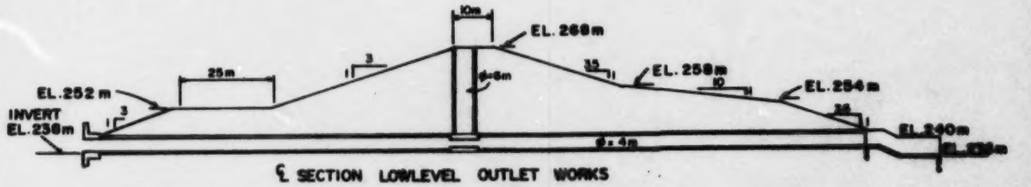




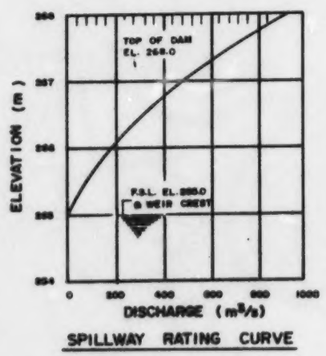
℄ SECTION SPILLWAY



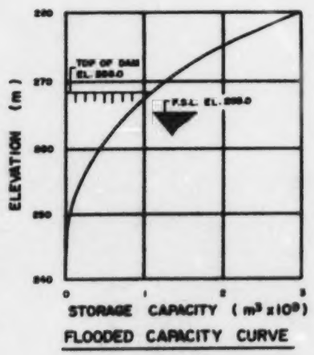
TYPICAL EMBANKMENT SECTION



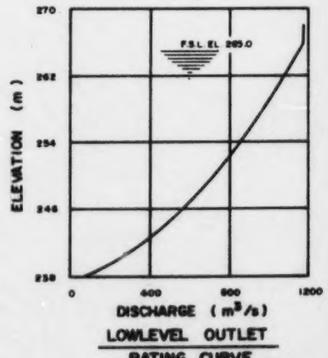
℄ SECTION LOWLEVEL OUTLET WORKS



SPILLWAY RATING CURVE



FLOODED CAPACITY CURVE



LOWLEVEL OUTLET RATING CURVE

CLEARWATER DAM GENERAL ARRANGEMENT AND DETAILS

Figure 4.5

disadvantage to this alternative would be the required staging since under current growth projections the road would not be required until the 1990's. The other aspects of this alternative would be similar to those of the previously examined dykes (see section 4.2.2).

4.2.8 Floodplain Zoning

This alternative is a non-structural alternative which would consist of appropriate legislative actions to control development within the floodplain. Such control is usually exercised at the provincial level and currently there is no established provincial policy with respect to floodplain management although a policy document is under consideration. Under this category three options were examined -- progressive removal of non-conforming uses, no growth and selected growth.

As a stand alone alternative the major disadvantage of very restrictive flood plain zoning is the disruption to the social, cultural and economic life of the city. It is the stated intent of the City of Fort McMurray that the central business district continue as such, and further that it will expand in accordance with the future demand for commercial and retail space. The flood area is the heart of the city and contains the major elements of the existing and proposed transportation system. If floodplain zoning is used in conjunction with a structural alternative a much less restrictive zoning would be required.

4.2.9 Relocation

This alternative is a common and often appropriate solution to floodplain development especially after a major disaster, but in the City of Fort McMurray it represents a monumental exercise which is not at all cost effective. Specifically, the option entails the removal and relocation of every structure located below elevation 252 m.

The cost of this alternative was estimated to be $365 million. The resulting benefit-cost ratio is 0.15. The disadvantages of this alternative are the massive social disruption that would occur and the increased linear development that would be required to accommodate the relocated buildings. The advantages of the alternative are that it is easy to understand and completely solves the flooding problem.

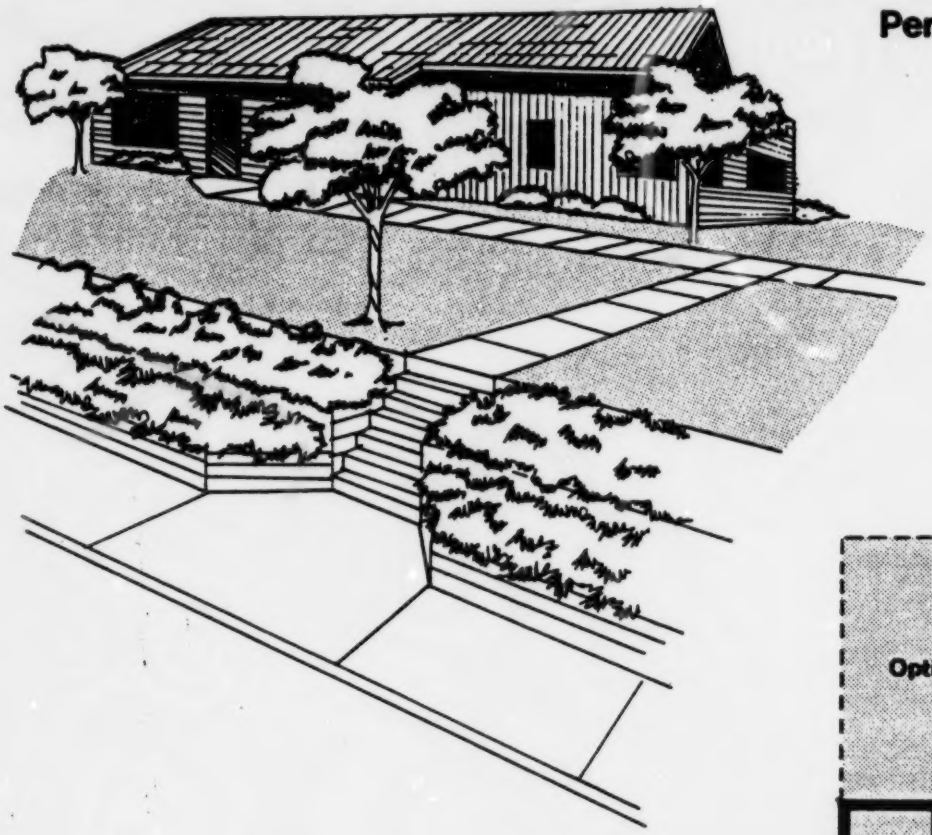
4.2.10 Flood Proofing

This alternative attempts to raise, wherever possible, houses and buildings up out of flood danger. A number of small structural measures exist that could remove some of the structures from flood damage. The most common method is to raise the elevation by constructing on fill (see Figure 4.6). There are, however, other means such as seals and closures which would also reduce the damage.

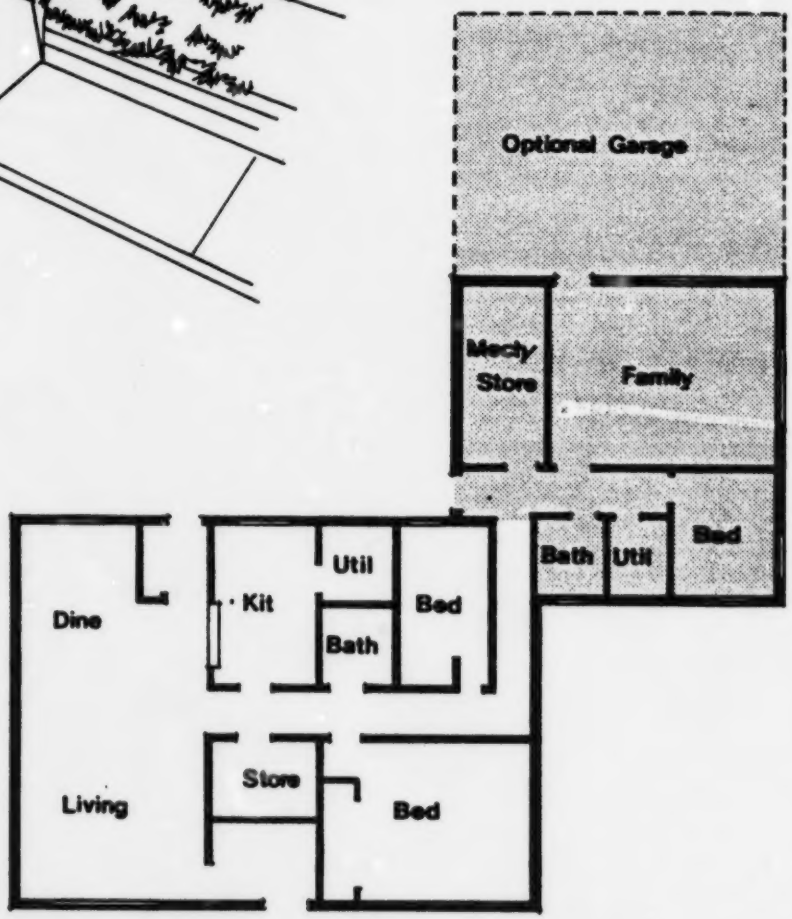
The total cost to upgrade the flood prone area would be $333 million. This results in a benefit-cost ratio of 0.19. As well, there would be considerable social disruption.

4.2.11 Downstream Blasting

Flooding from the formation of ice jams can occasionally be reduced by using explosives to free the ice jam. The ice jams which are created



Perspective View



Typical Plan (BW)

ELEVATION ON FILL

Figure 4.6

downstream of Fort McMurray are not the type that can be moved by blasting. Although blasting has been tried on a number of occasions in the City the general consensus is that it has been ineffective.

Although blasting is relatively inexpensive, it would not be able to provide the same level of protection as the other measures and consequently costs and benefits cannot be calculated.

4.2.12 Contingency Measures

This alternative consists of a combination of flood forecasting, warning and emergency measures. The purpose is to reduce the flood damage as much as possible and to eliminate the risk of loss of life. It is not a stand alone alternative as it does not solve the flooding problem. It can however be considered an improvement over a do nothing alternative. Regardless of any structural and/or non-structural flood damage reduction measures, contingency measures must be formulated and in place in the event of a catastrophic flood causing failure of any of the structural measures. Currently, a city evacuation plan and a new set of attendant emergency measures are in place.

Economic efficiencies could not be computed for this alternative since contingency measures do not form a complete alternative. It would, however, form an integral part of any floodplain management plan.

4.3 COMPARISON OF ALTERNATIVES

Each alternative listed in the previous section has a number of advantages and a number of disadvantages. A ranking of alternatives must be carried out to consider both economic and non-economic factors. The economic factors are fairly straightforward and consist of economic

cost and efficiency. Non-economic factors include such things as potential loss of life, biophysical, social and aesthetic factors and ease of implementation. A matrix scoring system was developed for both economic and non-economic factors and the results of the ranking appear as Tables 4.3.1 and 4.3.2.

The results of this ranking are as follows:

Economic Objectives:

First	- Dyking outside the river channel.
Second	- Dyking inside the river channel.
Third	- Ring road and dyke.

Non-economic Objectives:

First (tie)	- Dyking outside the river channel.
	- Relocation .
Second	- Dyking inside the river channel.
Third	- Ice control structure.

ALTERNATIVES	ECONOMIC EFFICIENCY				
	PROJECT COSTS $1,000	PROJECT BENEFITS $1,000	NET BENEFITS $1,000	B/C	RANK
1. Ice Control Structure	81,700	52,802	-28,898	0.65	4
2. Dyking Inside River	28,500	46,112	17,612	1.62	2
3. Dyking Outside River	20,000	46,112	26,112	2.30	1
4. Channel Improvements	N/A	N/A	N/A	N/A	N/A
5. Storage Crooked Rapids*	710,000	N/A	N/A	N/A	N/A
6. Storage Clearwater	87,300	52,802	-34,398	0.61	5
7. Ring Road and Dyke**	52,200	46,112	-6,088	0.88	3
8. Flood Zoning	N/A	N/A	N/A	N/A	N/A
9. Relocation	365,577	55,833	-309,743	0.15	10
10. Flood Proofing-Fill	332,581	63,048	-269,533	0.19	9
11. Flood Proofing-Foundation	309,487	63,048	-246,439	0.20	8
12. Flood Proofing-Seals & Cls.	137,392	31,681	-105,711	0.23	7
13. Flood Proofing-Seals & Cls.	112,419	31,618	-80,738	0.28	6
14. Downstream Blasting	N/A	N/A	N/A	N/A	N/A
15. Contingency Measures	N/A	N/A	N/A	N/A	N/A

* Medium Head

** Low Growth Scenario

COMMENSURABLE OBJECTIVES

Figure 4.3-1

ALTERNATIVES	DISASTER PREVENTION				ENVIRONMENTAL IMPACT					
	REDUCES CURRENT LOSSES	REDUCES FUTURE LOSSES	POTENTIAL RESIDENTIAL L.-O.-L.*	POTENTIAL NON-RESIDENTIAL L.-O.-L.*	BIO-PHYSICAL	SOCIAL	AESTHETIC	IMPLEMENTATION	INCIDENTAL BENEFITS	RANK
1. Ice Control Structure	H	H	L	L	H	VL	M	M	M	3
2. Dyking Inside River	H	H	M	M	M	L	VL	L	M	2
3. Dyking Outside River	H	H	M	M	VL	L	VL	L	M	1
4. Channel Improvements	L	L	H	H	H	VL	M	L	L	8
5. Storage Crooked Rapids*	VH	VH	L	L	VH	VL	M	VH	H	4
6. Storage Clearwater	H	H	L	L	H	VL	H	H	M	5
7. Ring Road and Dyke**	L	M	M	M	L	L	M	M	M	6
8. Flood Zoning	VL	M	VH	VH	VL	M	VL	M	VL	9
9. Relocation	VH	VH	VL	VL	VL	VH	L	VH	H	1
10. Flood Proofing-Fill	H	H	L	L	L	H	H	VH	H	6
11. Flood Proofing-Foundation	H	H	L	L	L	H	H	VH	H	6
12. Flood Proofing-Seals & Cls.	M	M	L	L	L	H	H	VH	H	7
13. Flood Proofing-Seals & Cls.	M	M	L	L	L	H	H	VH	H	7
14. Downstream Blasting	VL	VL	VH	VH	L	VL	VL	VL	VL	8
15. Contingency Measures	L	L	L	L	VL	L	VL	M	VL	5

*L.-O.-L.: Loss-of-Life

NON - COMMENSURABLE OBJECTIVES

Figure 4.3-2

5.0 CONCLUSIONS AND RECOMMENDATIONS

The joint City of Fort McMurray/Alberta Environment Study Team has examined various solutions to the flooding problems in Fort McMurray. This work was completed in three phases. During the first phase of the study a detailed flood risk map was prepared. The second phase involved extensive surveying and accurate estimation of the flood damage potential. The flood damage potential, expressed as average annual damage, is estimated at $5.75 million. The third phase of the program examined structural and non-structual solutions to the flooding problem.

Based on the work outlined in this report, the Study Team has grouped the 12 alternatives into the following categories:

A. Preferred - dyke outside the river channel.
- dyke inside the river channel.

B. Technically feasible but Not Preferred - ice control structure upstream of the city.

C. Unacceptable - the 9 remaining alternatives.

The studies indicate that dyking is the preferred alternative from both an economic and non-economic objectives standpoint. It is expected that any dyke could, with the proper landscaping, be visually integrated into the cityscape. The only major disadvantages with any dyke is the increase in risk to life due either to the possibility of overtopping or structure failure of the dyke at some point along its length. Of the remaining alternatives, the ice weir is considered technically feasible but is not preferred because of its large construction costs, uncertainty as to its level of effectiveness and serious environmental impacts. The other alternatives are unacceptable for a variety of reasons which are summarized in this report (see section 4.2).

Extensive analysis was previously completed for the ice weir alternative. Further scientific and design work is required for the dyking alternatives to bring them to the same level of detail as the ice weir and to allow a more detailed assessment of benefits and costs. Consequently the following recommendation is made.

1. THAT DETAILED STUDIES BE CONDUCTED OF THE FOLLOWING FLOOD DAMAGE REDUCTION ALTERNATIVES:

- DYKING OUTSIDE THE RIVER CHANNEL, AND
- DYKING INSIDE THE RIVER CHANNEL

WITH SPECIAL ATTENTION TO THE FOLLOWING FACTORS:

- OPTIMAL ALIGNMENT
- RISK AND POTENTIAL LOSS OF LIFE: INCLUDING STUDY OF DYKE LEVELS HIGHER THAN THE 1:100 YEAR LEVEL, FLOOD FORECASTING AND LAND DEVELOPMENT CONTROLS.
- NEEDS FOR FURTHER PUBLIC INFORMATION PROGRAMS
- STRUCTURAL AND GEOTECHNICAL PROBLEMS
- INTEGRATION OF DYKE INTO TRANSPORTATION AND LAND USE PLANS
- NEEDS FOR LANDSCAPING AND PARKS
- POTENTIAL LAND ACQUISTION PROBLEMS.

The citizens of Fort McMurray will no doubt be interested in understanding the alternatives that were considered and how the Study Team reached its conclusion on the preferred alternatives to be considered in greater detail. The citizen will also have concerns and opinions on the two alternatives that should be considered prior to selection of an alternative. As well, once the most acceptable alternative has been chosen public input should be sought to ensure that

final design and implementation go smoothly and to confirm to the public that their concerns have been addressed. Consequently, the following recommendation is made.

2. THAT A WIDELY ADVERTIZED INFORMATION SESSION BE CONDUCTED IN THE NEAR FUTURE TO ADVISE CITIZENS OF THE FLOOD DAMAGE REDUCTION PROGRAM STATUS AND TO IDENTIFY PUBLIC CONCERNS AND OPINIONS ON THE TWO SELECTED ALTERNATIVES.